PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	10/689,001
Filing Date:	October 20, 2003
Applicant:	Gayatri Vyas et al.
Group Art Unit:	1745
Examiner:	Raymond Alejandro
Title:	ELECTRICAL CONTACT ELEMENT AND BIPOLAR PLATE
Attorney Docket:	GP-300791 (8540G-000236/COA)

DECLARATION UNDER 37 C.F.R. 1.132

I, Gayatri (Vyas) Dadheech, state as follows :

1. I am a joint inventor with Hubert A. Gasteiger and Youssef Mikhail who made application for a patent on October 20, 2003, which is the subject of the present application.

2. I received a Bachelor of Science degree in Chemistry, Botany, and Zoology from the University of Bhopal in 1987, a Master of Science degree in Chemistry with a minor in Electrochemistry from the University of Bhopal in 1989, and a Master of Science degree in Chemistry with a minor in Material Science from the University of Texas in 1995.

3. I have worked in the automotive industry for fourteen (14) years and with

fuel cells for eleven (11) years.

4. I have worked for General Motors Corporation since 1995, initially as a research engineer and since 1997 as a fuel cell engineer.

5. I have reviewed U.S. Patent No. 5,624,769 to Li et al., U.S. Patent No. 7,005,205 to Gyoten et al., and U.S. Patent No. 4,146,657 to Gordon in detail for their teachings and suggestions regarding our claimed bipolar plate assembly, which includes an electrically conductive contact element having an electrically conductive coating comprising a doped metal composition.

6. Gordon does not suggest to one skilled in the art that a doped metal oxide layer may be applied by his process to a metallic substrate consisting of, for example, aluminum, titanium, or stainless steel, and achieve low contact resistance between the layer and adjoining metallic substrate. Substrates consisting of stainless steel, aluminum, and titanium, unlike the glass substrates disclosed by Gordon, tend to oxidize in the presence of heat, such as that used by Gordon's process, causing a highly resistive oxide layer to form on the surface of the substrate.

7. Gordon discloses that the doped metal oxide layers formed by his process are useful for solar photovoltaic cells, photoconductive cells, liquid crystal electro-optical displays, photoelectrochemical cells, and other types of optical-electronic devices (Col. 1, lines 10-12). Importantly, electrochemical systems vary greatly. The environment of the solar cells disclosed by Gordon does not include the oxidizing and reducing gases (e.g., oxygen and hydrogen) and acidic compounds (e.g., per fluorocarbon sulfonic acid)

present in the fuel cell environment.

8. Un-doped tin oxide is unstable in the presence of the reducing gases (e.g., hydrogen) and the per fluorocarbon sulfonic acid present in the fuel cell environment and tends to form localized surface deposits of resistive tin oxide.

9. Li et al. discloses that layers of chromium, nickel, and molybdenum-rich stainless steels are useful as intermediate layers between a titanium nitride (TiN) topcoat layer and an aluminum or titanium substrate to inhibit corrosion of the substrate that may occur as a result of micro-discontinuities in the TiN topcoat layer. However, common oxides that form on compounds of stainless steel include hydrated iron oxide (i.e., rust) and chromium oxide, both of which exhibit high bulk and contact resistance. Li et al. discloses that the formation of dense oxide layers at the sites of the micro-discontinuities increases the fuel cell's internal resistance. Without detailed explanation, Li et al. maintains, however, that the fuel cell's internal resistance is not significantly increased. (Col. 3, lines 26-32). Implicit in this assertion is the limitation that the dense oxide layer forms only at the sites of the micro-discontinuities. Hydrated iron oxides and chromium oxide have contact resistance values of 300 and 500 milliohms-cm, respectively, and would significantly increase the resistance of the fuel if allowed to form more extensively within the conductive topcoat layer.

10. Oxygen and the per fluorocarbon sulfonic acid present in a fuel cell causes oxidation of exposed titanium nitride and the formation of a resistive titanium oxide surface layer.

11. Gyoten et al. discloses that the chromium oxides that form on a stainless steel sheet are electrically resistive, which supports the observations made in paragraph 9 above. (Col. 1, line 60 to Col. 2, line 2).

12. The conductive layer disclosed by Gyoten et al. illustrates the conventional wisdom and approach taken by skilled artisans where metallic oxides are present in the conductive elements of a fuel cell. While Gyoten et al. discloses a resin layer containing electroconductive particulate, such as ruthenium oxide (RuO_2), Gyoten et al. further discloses that the surface area of the particulate substance should be small to prevent increased contact resistance due to oxidation of the particulate. (Col. 4, lines 5-13). Thus, Gyoten et al. discloses a conductive layer that is resin rich at the exposed surface.

13. It is our experience, and we believe the experience of those skilled in the art of fuel cell design, that metal oxides, including tin oxide, generally do not possess the material properties required of the conductive elements of a fuel cell, including low electrical contact and bulk resistance.

14. Our efforts to develop a conductive element by applying a doped tin oxide layer to a bipolar plate assembly were contrary to the accepted wisdom and the prevailing approach in the field of fuel cell design at the time of our discovery. The conventional wisdom includes knowledge that un-doped tin oxide is unstable in the presence of the reducing gases (e.g., hydrogen) and the per fluorocarbon sulfonic acid present in the environment of the fuel cell and tends to form localized surface deposits of resistive tin oxide.

15. Absent from the teachings of Gordon are teachings of the unique anti-corrosion properties that can be achieved in tin oxide layers that have been doped with fluorine.

16. Passivating metals have been applied to metals susceptible to oxidation in the fuel cell environment (e.g., titanium or stainless steel) and metals that are susceptible to dissolution in the fuel cell environment (e.g., aluminum) to allow anti-corrosive metallic oxide layers to form, however these metallic oxide layers are known to be highly resistive. Topcoat layers, such as those disclosed by Li et al. and Gyoten et al., have been the conventional approach used to minimize the formation of such metallic oxide layers.

17. The technical problem we confronted includes providing a conductive layer on a metallic substrate capable of achieving and maintaining low contact resistance on a surface adjoining the substrate and an opposite surface exposed to the environment of the fuel cell and providing anti-corrosive properties that inhibit electrical degradation of the conductive layer.

18. During our experimentation with solutions to the above technical problem we began applying a doped metal oxide layer to the metallic substrates used in bipolar plates to see if a conductive layer exhibiting low contact resistance between adjoining surfaces could be achieved and to determine whether the layer and the interfaces between the layer and adjoining elements (e.g., substrate, PEM membrane) were susceptible to electrical degradation when exposed to the reactant gases and acidic compounds of the fuel cell. We experimented with temperatures at which the tin oxide layers were applied and the fluorine doping levels in an effort to achieve useful contact

resistance values. As a result of this experimentation, we learned that doping levels of between 0.5 and 1% (i.e., fluorine to oxygen ratios between .005 and .01) produced the lowest contact resistance and highest stability under the anodic and cathodic conditions of the fuel cell. We also learned that the surface of the substrate must be cleaned and polished to remove the presence of any metallic oxides before applying the doped tin oxide composition to the substrate. We learned that removal of the metallic oxides present on the surface of the substrate is important to achieving low contact resistance between the substrate and the doped tin oxide layer.

I, Gayatri (Vyas) Dadheech, hereby declare that the statements made herein of my own knowledge are true and that the statements made on information and belief are believed to be true. I declare further that these statements were made with the knowledge that willfully false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 the United States Code, and that any such willfully false statements may jeopardize the validity of the application and any patent issuing thereon, or any patent to which this declaration is directed.

Gayatri (Vyas) Dadheech

February 21, 2008
Date